DEVELOPMENT OF AN URBAN STREET NEEDS STUDY

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by

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and

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Joint Highway Research Project

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LAFAYETTE INDIANA

Technical Paper

DEVELOPMENT OF AN URBAN STREET NEEDS STUDY

To: G. A. Leonards, Director
Joint Highway Research Project

May 11, 1967

File: 3-3-35

From: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-54II

The attached Technical Paper entitled "Development of an Urban Street Needs Study" authored by R. G. Rude and J. C. Oppenlander of our staff was presented at the International Road Federation Middle East Meeting in Beirut, Lebanon. It has been offered for publication in the Proceedings of that meeting.

The paper is a summary of the final research report entitled "Formulation of a Technique for Evaluating Urban Highway Needs" presented by Mr. Rude to the Board in October 1965. The paper presents a technique used in West Lafayette to evaluate the street needs of that city.

The paper is presented to the Board for approval of the proposed publication.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

HLM:jgs

Attachment

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School of Civil Engineering

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May 1967

DEVELOPMENT OF AN URBAN STREET NEEDS STUDY

SUMMARY

A typical city spends between 20 and 30 percent of its operating budget for transportation purposes. Of this amount, about 70 percent is allocated to the planning, design, construction, operation, and maintenance of the street system. If such large sums of money are expended for urban transportation, this investment should be allocated to maximize the benefits returned to the road users, the abutting property, and the general public. Efficient and economical techniques should be used to determine the transportation needs of a community and the priorities for their improvement.

The purposes of this field investigation were to develop a rational technique for the conduct of an urban street needs study and to evaluate the use of sampling procedures as applied to this needs study to determine the reliability of the cost estimates obtained. The facilities analyzed in this investigation were the arterial and collector streets and the major intersections in West Lafayette, Indiana.

The study process involved the completion of the following eight basic steps:

1. Classification of streets into systems according to the functions performed in serving traffic demands;
2. Development of design and tolerable standards;
3. Inventory of each street section and intersection to describe its physical characteristics and its traffic load;

4. Determination of present street and intersection deficiencies and those which are expected to develop within the 20-year study period;
5. Determination of the physical improvements needed to overcome the present and future deficiencies;
6. Estimation of the costs of needed improvements;
7. Establishment of priorities for improvements; and
8. Application of statistical considerations to determine if reliable cost estimates can be obtained by sampling techniques.

This procedure provides a rapid, accurate, and inexpensive means of determining the physical and financial needs of an urban transportation system for communities of small and medium size.

INTRODUCTION

Determination of the transportation needs for a city has become a major problem in the past few years. An efficient, economical and precise method of determining the transportation needs of an urban community is essential if the urban centers are to solve their ever-increasing transportation problems in a rational manner. Included in this transportation planning is a study of street and highway needs.

Most cities have attempted to solve their transportation problems with a typical engineering approach, which requires a detailed evaluation of all facilities. That is, each section of the street system is analyzed in detail to determine the structural, geometric and safety deficiencies. This procedure is very costly and time consuming and should be continually updated. Most cities have neglected this phase of urban planning because of the excessive manpower and cost requirements. Thus, it has become increasingly important for highway engineers, governmental officials, planners and traffic engineers to have a rapid, accurate and inexpensive means of determining urban transportation needs.

Some new concepts are evidently needed in the field of urban needs studies if cities are to solve their transportation problems. The major objectives of this study were as follows:

1. Make a complete inventory and traffic evaluation of the arterial and collector streets in West Lafayette, Indiana,
2. Determine the cost of eliminating the deficiencies in the major street system at five-year intervals over a twenty-year period, and
3. Evaluate the use of sampling techniques as applied to this needs study to determine if reliable cost estimates can be obtained.

There are many advantages to be gained through progress in the field of urban transportation needs studies. Efficient and economical techniques can be developed for determining municipal needs. Current data can be provided concerning the urban street network by means of sampling procedures. Urban needs studies will aid in the prediction and planning of future land use within a city. Needs studies will also assist in making expenditure estimates so that proper financial planning can be accomplished.

PROCEDURE

The design of the study, the methods employed in the data collection and the analysis of the data are discussed in this section of the report. The facilities analyzed in this investigation were the arterial and collector streets and the major intersections in West Lafayette, Indiana.

Design of Study

The initial approach to this investigation was similar to that followed in most previous urban needs studies - the typical engineering analysis in which each section of street and each intersection were thoroughly analyzed. The following major items were considered on all arterial and collector street sections and at each important intersection:

1. Volumes - present and future,
2. Character of traffic,
3. Travel time and delay,
4. Parking,

5. Accidents,
6. Traffic signs and markings,
7. Traffic signals,
8. Channelization,
9. Geometric Design, and
10. Street and intersection lighting.

The appraisal procedure involved a section by section analysis of the system to determine the costs of improving all deficient streets and intersections to design standards adequate for present and future traffic.

The study process consisted of the following basic steps:

1. Classification of streets into systems according to the functions performed in serving traffic demands,
2. Development of design and tolerable standards,
3. Inventory of each street section and intersection to describe its physical characteristics and its traffic load,
4. Determination of present street and intersection deficiencies and those which are expected to develop within the twenty-year study period,
5. Determination of the physical improvements needed to overcome the present and future deficiencies,
6. Estimation of the costs of needed improvements,
7. Establishment of priorities for improvements, and
8. Application of statistical considerations to determine if reliable cost estimates can be obtained by sampling techniques.

Functional Classification

An investigation of existing street usage is the first step in a comprehensive urban needs study. Street classification is the orderly grouping of street sections into systems which provide similar services. A functional classification provides the basis upon which financial plans can be devised, management requirements defined, street responsibilities established and improvement programs formulated.

For this study the streets were grouped into the three functional categories of arterial, collector and local streets. Many studies include expressways as a fourth category, but in this investigation no existing street sections were classified under this heading. The arterial and collector street systems and the intersections studied are indicated in Figure 1.

Design and Tolerable Standards

Design and tolerable standards were developed in this investigation for the determination of the urban highway needs. Tolerable standards are a set of measurable conditions used to determine the acceptability of a street system. Tolerable standards are not as high as the standards which control new construction or reconstruction but are scaled-down versions of construction standards and provide for acceptable conditions and reasonable, economical and safe travel.

Design standards are a set of street and intersection design practices which are used on all new construction and on the reconstruction of inadequate facilities. The standards used throughout this study were developed from a number of sources which included the American Association

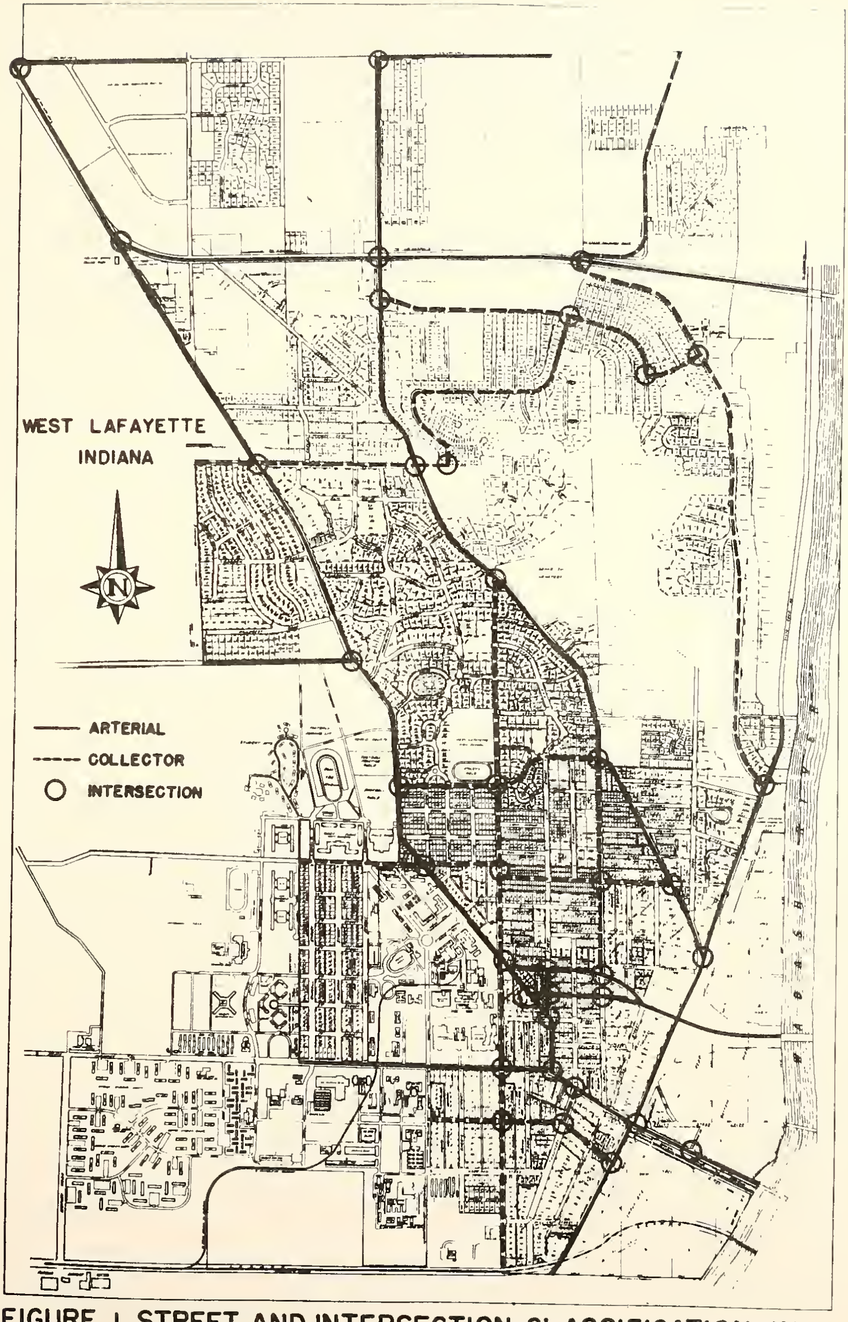

FIGURE 1. STREET AND INTERSECTION CLASSIFICATION IN WEST LAFAYETTE

of State Highway Officials standards and the recommendations of the National Committee on Urban Transportation.

Forecasts

The steady growth in the use of motor vehicles has compounded the problem of traffic congestion in urban areas. This increase in automobile usage has an effect on the present street system as well as greatly influencing the size and type of new facilities needed to meet future demands. To determine the improvements required and the traffic demands on the transportation system of the future, it is necessary to have an accurate estimate of future traffic volumes.

For the purposes of this investigation, all forecast items were expanded on a straight-line basis. No consideration was given to the reduction of the growth rate with an increase in time. The method used to predict the traffic increase in this study was based on the three component factors of population, motor-vehicle registration and motor-fuel consumption. The predicted increase in traffic flow equals the product of the estimated increases of the three individual factors during the twenty-year study period. Factors were also obtained for five-, ten- and fifteen-year periods.

Collection of Data

The data collection phase of this investigation consisted of gathering various traffic and physical road information for each street control section and each major intersection. The basic data included the physical inventories of the street sections and intersections, volume counts, speed

and delay information and accident characteristics.

Physical Inventories

The purpose of an inventory of an urban street system is to provide a complete record of the physical features and the service demands on each section of street and at each intersection. Information of this nature is essential if accurate needs estimates and the location of necessary improvements are to be determined. In this study, four separate inventory forms were prepared, to obtain all necessary information concerning the street system. These inventory sheets are the Arterial Street Evaluation Form, the Local Street Evaluation Form, the Intersection Evaluation Form and the Arterial Structure and Railroad Evaluation Form. As an example, the Arterial Street Evaluation Form is shown as Figure 2.

Each major intersection in the city was measured in detail, and all buildings, utilities and traffic control devices were located on scaled drawings of the intersections. These drawings provided a working diagram from which deficiencies could be determined when combined with the intersection inventory forms. An example of one intersection is the drawing presented as Figure 3.

Volume Study

Volume data are used in specifying the size of the geometric design of facilities, in determining the degree of congestion on the city street system and in the location of various traffic control devices. An increase in volume on a given facility over a period of time produces an increase in travel time, an increase in accidents and a reduction in

IDENTIFICATION

1. CITY ______ 2 POPULATION ______ 3. COUNTY ______
4. STREET SECTION NO. ______ 5. LENGTH ______
6. STREET NAME ______ FROM ______ TO ______

CLASSIFICATION

7. EXISTING FEDERAL AID SYSTEM
   - INTERSTATE HIGHWAY ☐
   - PRIMARY ☐
   - SECONDARY ☐
   - NON FEDERAL ☐

8. STUDY SYSTEM
   - URBAN STATE PRIMARY ☐
   - URBAN STATE SECONDARY ☐
   - ARTERIAL PRIMARY ☐
   - ARTERIAL COMMUNITY ☐
   - COLLECTOR (30) ☐
   - COLLECTOR (40) ☐

EXISTING STREET AND TRAFFIC DATA

9. NO OF LANES
10. SURFACE TYPE ______
11. SURFACE WIDTH ______ FT.
12. RIGHT OF WAY WIDTH ______ FT.
13. BUILDING SETBACK ______ FT.
14. ESTIMATED ADT ______ VPD
15. ESTIMATED DHV ______ VPH
16. PRACTICAL CAPACITY ______ VPD
17. % COMMERCIAL VEHICLES ______ %
18. YR. PVT. OR LAST RESURFACED ______
19. ESTIMATED REMAINING SURFACE LIFE ______ YR.
20. SPEED LIMIT ______ MPH
21. NO OF TRAFFIC SIGNAL
    - FIXED TIME ______
    - PROGRESSIVE ______
    - TRAFFIC ACTUATED ______
    - PEDESTRIAN ______
22. STOP SIGNS DIRECTED TO ARTERIAL TRAFFIC (NO OF INTERSECTIONS)
    - 4 - WAY ______
    - 2 - WAY ______

	NONE	1 SIDE	2 SIDES
23. FIRE HYDRANTS	☐	☐	☐
24. UTILITY POLES	☐	☐	☐
25. CURBS	☐	☐	☐
26. DITCHES	☐	☐	☐
27. SIDEWALKS	☐	☐	☐
28. PARKING	☐	☐	☐

29. IF PARKING PERMITTED
    - PARALLEL ALL TIME ☐ OFF PEAK ONLY ☐
    - DIAGONAL ALL TIME ☐ OFF PEAK ONLY ☐
30. STORM SEWERS NONE ☐ IN PLACE ☐
31. STREET LIGHTS
    - NONE ☐
    - INTERSECTIONS ☐
    - CONTINUOUS ☐
32. STREET OPERATION
    - ONE - WAY ☐
    - TWO - WAY ☐
33. TYPE OF ACCESS CONTROL
    - NONE ☐
    - PARTIAL ☐
    - FULL ☐

DEFICIENCIES

	PRESENT	TIME OF IMPROVEMENT 5 YR.	10 YR.	15 YR.	20 YR.	OVER 20 YR.
34. SURFACE TYPE	☐	☐	☐	☐	☐	☐
35. SURFACE WIDTH	☐	☐	☐	☐	☐	☐
36. SURFACE CONDITION	☐	☐	☐	☐	☐	☐
37. BASE CONDITION	☐	☐	☐	☐	☐	☐
38. CROWN	☐	☐	☐	☐	☐	☐
39. INTERSETION CONTOUR	☐	☐	☐	☐	☐	☐
40. CURBS	☐	☐	☐	☐	☐	☐
41. DRAINAGE	☐	☐	☐	☐	☐	☐
42. ILLUMINATION	☐	☐	☐	☐	☐	☐
43. SIDEWALKES	☐	☐	☐	☐	☐	☐
44. TRAFFIC CAPACITY	☐	☐	☐	☐	☐	☐

PROPOSED IMPROVEMENTS

DESIGN DATA

DESCRIBE

45. TYPE OF WORK
    - RESURFACE ______ MI.
    - WIDEN ______ MI.
    - BASE & SURFACE ______ MI.
    - NEW CONSTRUCTION ______ MI.
46. TOTAL LENGTH ______ MI.
47. WIDENING WIDTH ______ FT.
48. SURFACE TYPE ______
49. SURFACE WIDTH ______ FT.
50. NO. OF LANES ______
51. ESTIMATED 1985 DHV ______ VPH
52. ESTIMATED 1985 ADT ______ VPD
53. NO. OF STRUCTURES ______
54. CURBS YES ☐ NO ☐
55. SIDEWALKS YES ☐ NO ☐
56. PARKING YES ☐ NO ☐
57. ACCESS CONTROL (TYPE) ______
58. DRAINAGE ______
59. ILLUMINATION ______

COST ESTIMATES

	DOLLARS
60. RIGHT OF WAY	______
61. GRADE & DRAINAGE	______
62. BASE & SURFACE	______
63. STRUCTURES	______
64. TRAFFIC CONTROL	______
65. OTHER	______
66. TOTAL	______

FIGURE 2. ARTERIAL STREET EVALUATION FORM

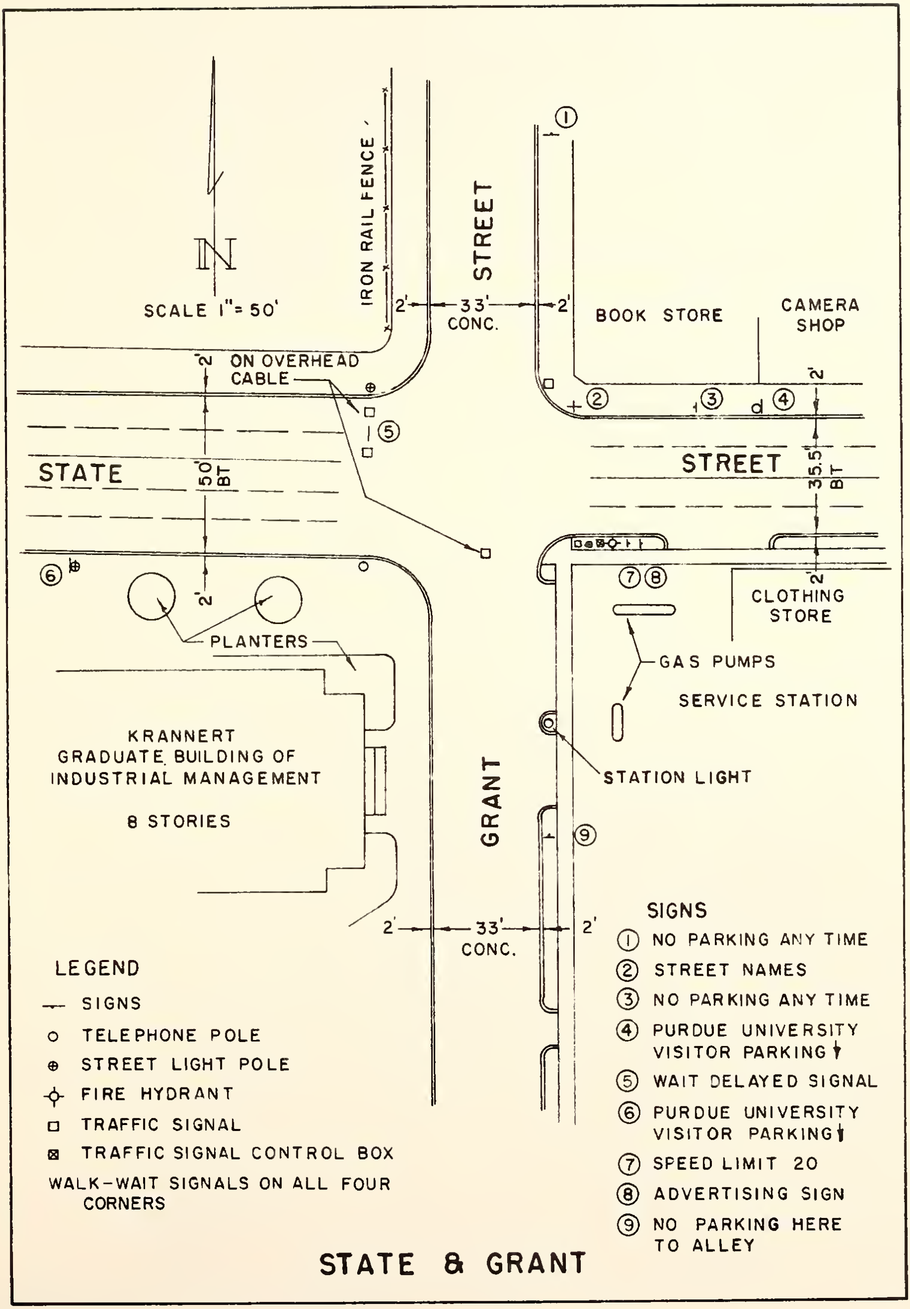

FIGURE 3. INTERSECTION DIAGRAM

operating efficiency. Thus, all possible measures should be taken to relieve congestion, and a street network should be designed to handle adequately the traffic which is expected to occur in the future.

Two control stations for continuous counts were established in the traffic counting procedure - one on an arterial street and the other on a collector street. On the remaining street sections considered in this investigation, a sampling technique was employed to ascertain the 24-hr traffic volume. Two one-half hour counts were made on each street section, and these counts were converted to average daily traffic values using the control counts as a base. The derived average daily traffic volumes are shown in Figure 4 as a traffic-flow diagram. Other volume information which was collected for this study included turning movements at all major intersections and the percentage of commercial vehicles on each street section. The percentage of commercial vehicles and the turning movements were used in the determination of street deficiencies and needs.

Speed-Delay Study

The automobile driver often measures the desirability of a route by the time required to reach his destination; that is, he usually selects the route which minimizes the travel time. Travel time and delay studies provide information concerning the amount, cause, location, duration and frequency of delays as well as travel time between various terminals. Travel time and delay data can also be used to determine where various deficiencies exist in the street network and may indicate the type of improvement required.

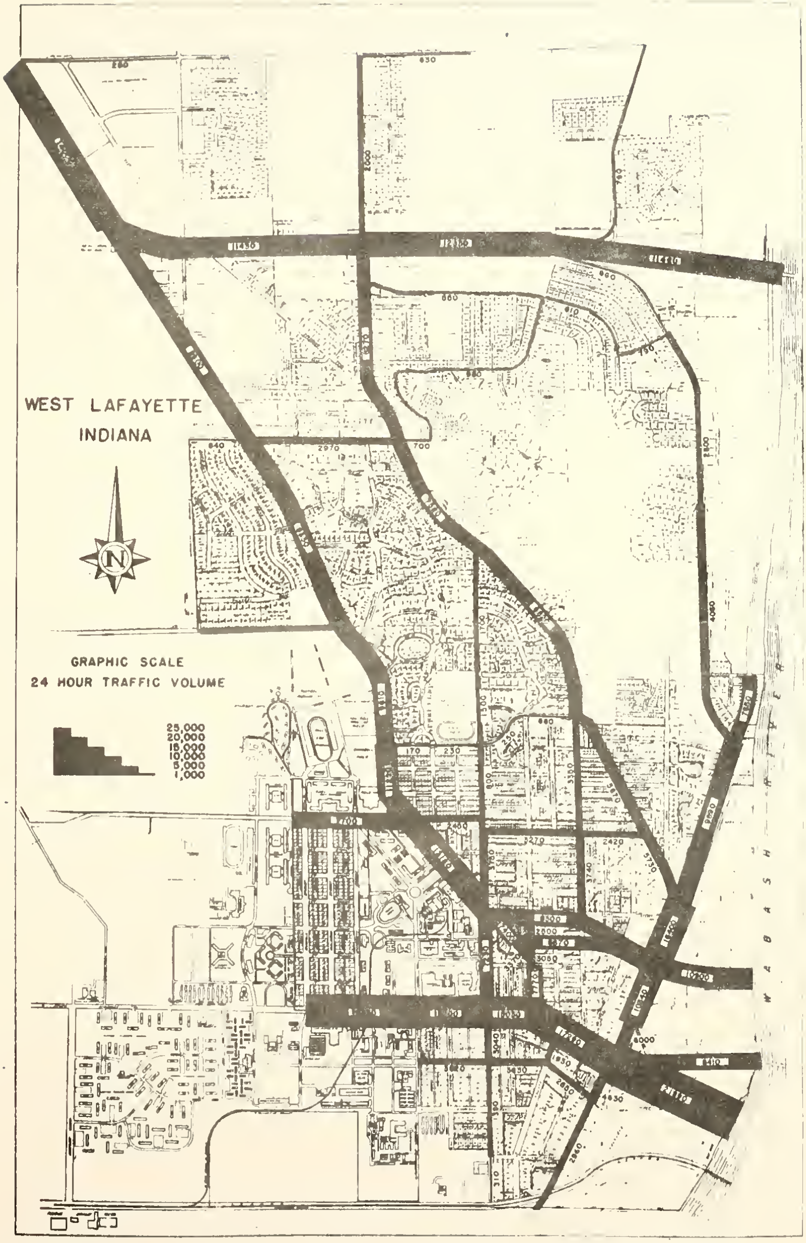

FIGURE 4. AVERAGE DAILY TRAFFIC FLOW IN WEST LAFAYETTE

The "average speed" method was used to obtain the speed and delay data for this study. The driver of the test car in this technique travels at a speed that, in his opinion, is representative of the speed of all traffic at the time of the test run. The runs were made under normal weather conditions in the direction of the predominant peak-hour flow. All runs were made on a weekday (Monday through Friday), so traffic conditions were about the same for each test run.

Accident Study

The location and type of accidents are major indicators of where deficiences exist in the street network. Through accident studies overall geometric design can be improved to make it more difficult for drivers to get into trouble. For example, the studies may indicate where medians, access control, signs or signalization are required. Other uses of accident studies include application in evaluating different designs, in before-and-after studies and in the computation of economic losses due to the lack of safety.

The six basic steps followed in the study of accident experience at the selected locations in West Lafayette were:

1. Obtaining adequate vehicle accident reports,
2. Selecting high-accident locations,
3. Preparing collision and condition diagrams for each location,
4. Summarizing the accidents along the street sections and intersections,
5. Supplementing accident data with field observations of traffic conditions during hours when most collisions occurred, and

6. Analyzing the summarized facts and field data to prescribe remedial treatment.

Analysis of Data

This section of the study deals with three basic topics: determination of deficiencies, cost estimates and sampling techniques. The methods by which the collected data were used to determine street system deficiencies are described. Techniques are also discussed for calculating the cost of street needs for various future time periods. The final portion in the analysis phase deals with the development of sampling procedures for estimating municipal street improvement costs.

Determination of Deficiencies

The primary data in each of the street section files, before an analysis had been made, included the inventory sheet, the estimate of the average daily traffic and information on travel time and delays over the section. The information in the intersection files consisted of the inventory sheet, estimated approach volumes on each branch of the intersection, peak-hour turning movements, a three-year accident summary, collision diagrams, signal-timing chart and a scaled drawing of the intersection.

Inventory. The deficiencies were determined by comparing the inventory data with the corresponding tolerable standards. These comparisons indicated whether or not the street sections or intersections were presently deficient. It was assumed that reconstruction could not be economically justified if the section or intersection under study could still serve traffic in an economic and safe manner. The nature

and time of expected future deficiencies were estimated for those sections which were tolerable but did not meet the design standards. To determine these future needs, use was made of various road-life studies and the traffic growth forecast for the city. All sections which were not tolerable in accordance with the specified standards were designated as being deficient at the present time. Present deficiencies should ideally be reconstructed to design standards if the financial resources are available.

All physical features of the street system, including everything within the right-of-way such as curbs and gutters, sidewalks, utilities, traffic-control devices, sight distances, etc., were given consideration in this physical needs determination. Where these items did not meet the proper standards, corrective measures were recommended to eliminate the existing deficiencies.

Traffic Movement. The same procedure which was used for the inventories was applied for the determination of deficiencies in connection with traffic movement. The existing conditions were compared with the developed tolerable standards to determine the present needs. The basis for all future estimates was the traffic growth factors developed in this study. From these traffic estimates a determination was made as to when future improvements are needed in the street system.

The items which were investigated on each street section and at each intersection were volumes, turning movements, percentage of commercial vehicles and the results of the speed-delay study. Volumes were studied on each street section and compared with the practical capacities of each street and intersection approach. Where the capacities were exceeded or

are exceeded at some time in the future, necessary improvements, such as elimination of parking, street widening, rerouting of traffic or the establishment of one-way streets were specified to eliminate the capacity deficiencies. Turning movements were investigated at each intersection with consideration given to signing, pavement markings and the possibility of eliminating some turns to provide safer and faster traffic flow. An investigation of the speed-delay study revealed locations where street improvements and traffic control devices could be employed to move traffic in a more efficient manner.

Accidents. The accident analysis which was conducted in West Lafayette indicated that many accidents were related to a probable cause. Using all available information, an attempt was made to define accident patterns and traffic hazards at each study location.

The collision and condition diagrams for each intersection were very useful in revealing accident types and causes. Collision and condition diagrams were also drawn for a few street sections which had an unusually high number of accidents. After the necessary information was collected (collision and condition diagrams, summary accident reports and field observations), an analysis was made of each location. Accidents were summarized by type for each intersection, and this classification indicated in many cases the causes and necessary remedies.

Priority Rating

The street sections and intersections investigated in this study were arranged in the order in which they should be improved. The rating method used was the Street Improvement Priority Rating developed for West Lafayette, Indiana. This system was revised for the purposes of this study so inter-

sections could be rated as well as street sections.

Cost Estimates

After the deficiencies were computed for each street section and intersection, the costs of the needed improvements were estimated to determine the financial needs. A list was made of the needs for each section and the time by which they should be completed was determined. The cost of each required improvement was then calculated using current prices.

Development of Sampling Techniques

Sampling procedures were applied to the present improvement costs required for the street sections and intersections. Sampling of the street sections and intersections was not investigated for future time periods because of the insufficient number of cost values. This same restriction was applicable to the structure and railroad crossings for all time periods.

The purpose of the statistical considerations was to determine if reliable cost estimates could be obtained by sampling techniques. It was desired to estimate the total cost of improving the street sections and intersections in a given classification by determining the cost for a random sample of these locations. To obtain the total cost of a population, the mean of the sample was calculated and multiplied by the number of sections in that particular category. The investigated populations were structured according to the various street and intersection classifications. The populations were sampled separately because of the large variability in the cost values among the different categories.

The standard deviation was calculated for each population category. Samples of size 10, 20, 30, 40, 50, 60, 70, 80 and 90 percent were considered for each population. The standard error of the mean was then obtained for each sample size in a given population class. The percentage of sample size versus the standard error of the mean, in terms of the cost of improvement, was developed and plotted for each population category. Using these graphs it is possible to predict the amount of error to be expected in estimating the total cost of improving a given class of streets or intersections using a known sample size in West Lafayette, Indiana.

RESULTS

This section of the report summarizes the major findings in connection with the physical street system needs in West Lafayette, Indiana and the financial requirements necessary to improve present and future deficiencies within this community. The sampling study investigated the reliability of estimating total financial needs with a sample survey of randomly selected street sections and intersections.

Physical Needs

A portion of the data from the street inventory and condition survey is summarized in Figure 5. Of the 21.43 miles of arterial and collector streets in the West Lafayette system, 4.04 miles or approximately 19 percent were rated as needing resurfacing, reconstructing or widening at the present

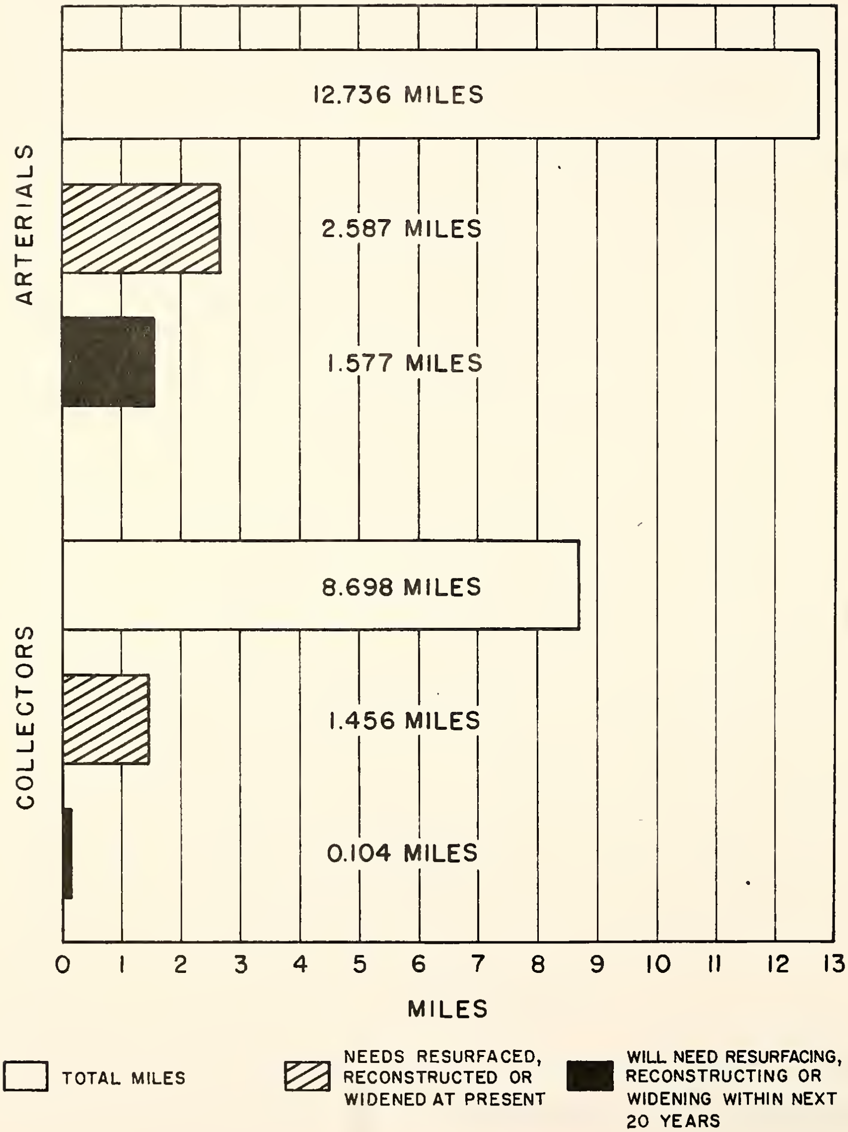

FIGURE 5. MILES OF NEEDED WORK IN WEST LAFAYETTE

time. Within the next twenty years an additional 8 percent of these streets will require reconstruction or widening. Curbs and gutters need replacing along many street sections and at some of the intersections. Sidewalks are needed along many streets where they do not exist, and at some locations the sidewalks need replacing.

One major need in connection with traffic movement is the elimination of on-street parking along many street sections. This need for eliminating parking will increase with time as the volumes of traffic on the streets increase.

Priorities

Using the Street Improvement Priority Rating developed for West Lafayette, Indiana, lists of street sections and intersections were prepared as tools in determining priorities of improvement. The locations of a portion of the needed improvements and their priorities are shown in Figures 6 and 7, respectively, for street sections and intersections.

Financial Needs

The total cost required to improve all present deficiencies in the arterial and collector streets and at the 38 major intersections in West Lafayette was calculated to be $462,236.00. An additional $79,051.50 will be needed during the next twenty years to meet the future demands of the traffic in this community.

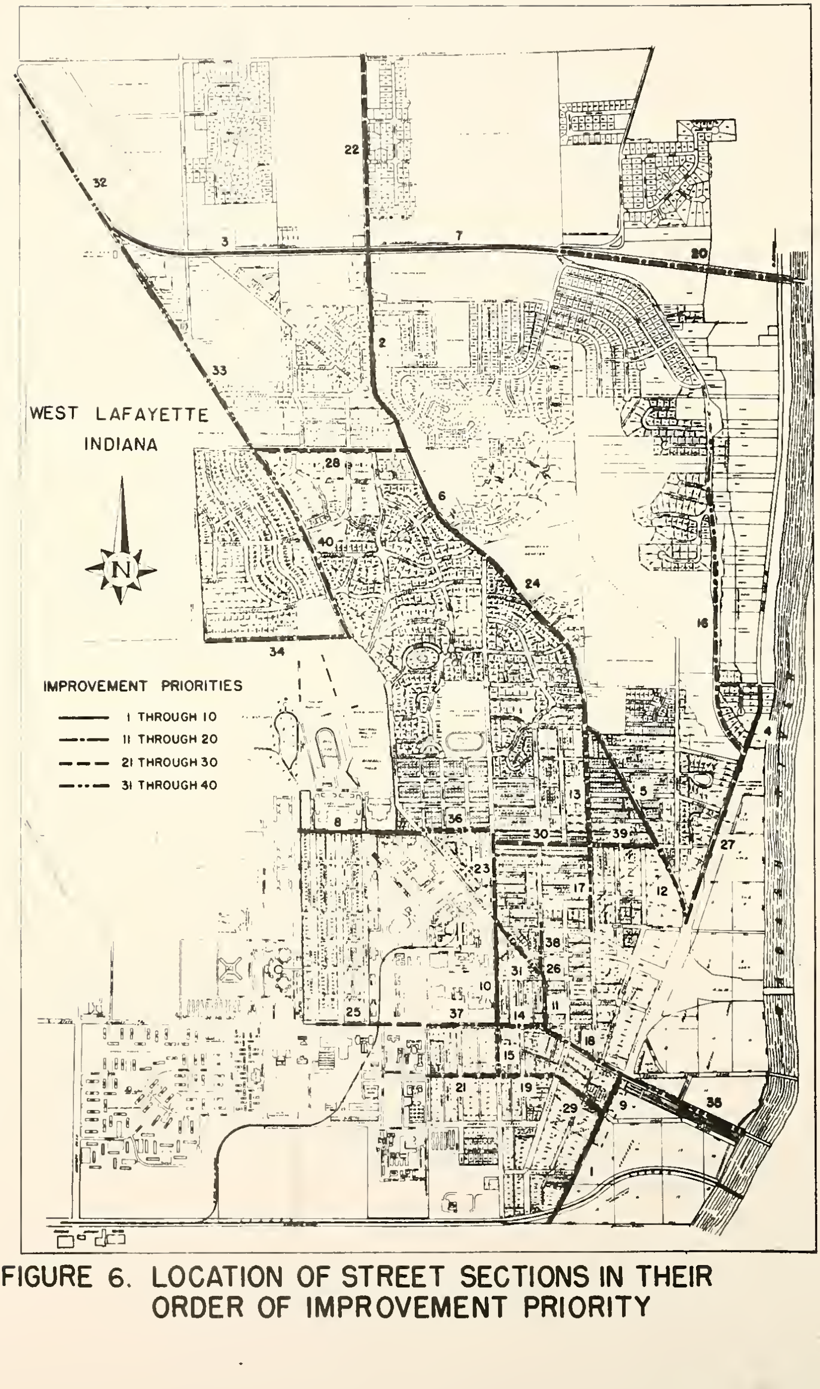

FIGURE 6. LOCATION OF STREET SECTIONS IN THEIR ORDER OF IMPROVEMENT PRIORITY

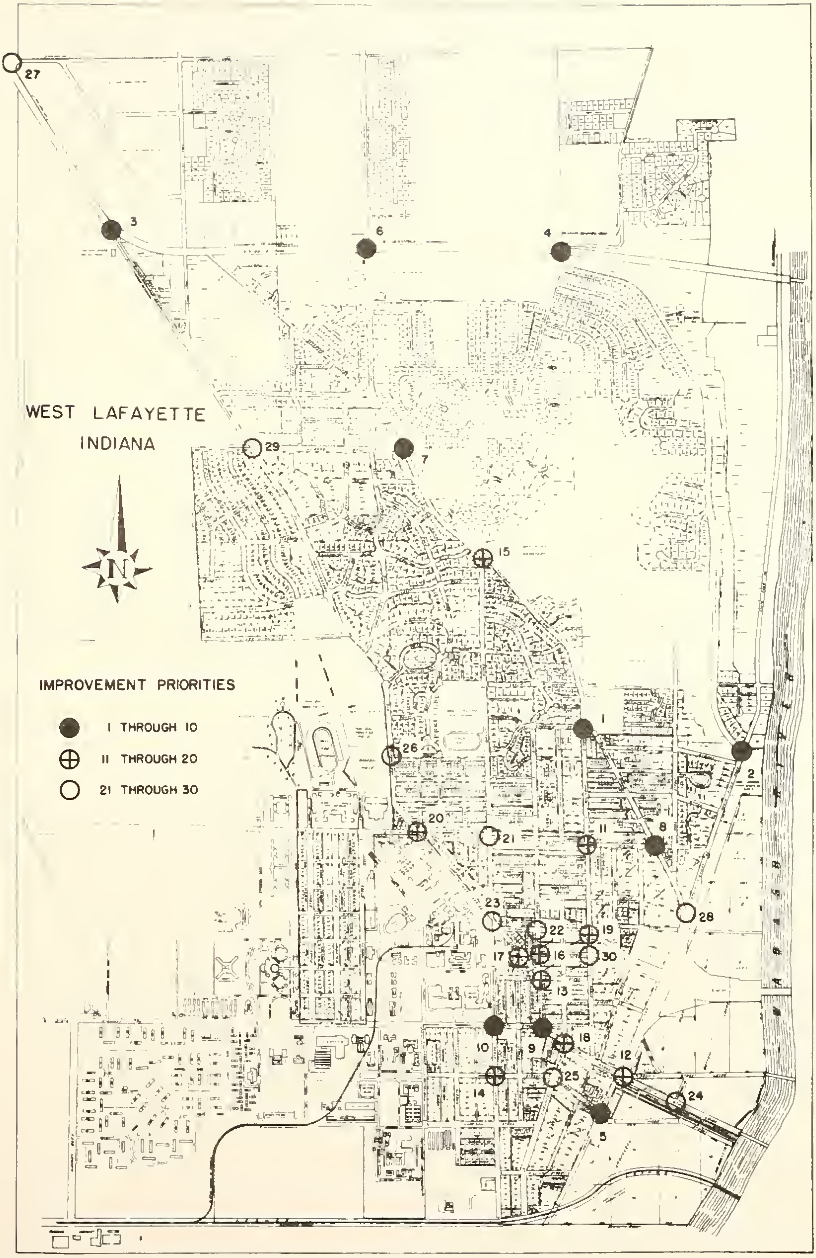

FIGURE 7. LOCATION OF INTERSECTIONS IN THEIR ORDER OF IMPROVEMENT PRIORITY

Sampling

The results of the sampling survey are illustrated in Figure 8 for one of the seven cases investigated in this study. These graphs present the percentage of sample size versus the standard error of the mean in terms of the cost required to improve the present deficiencies in the street sections and intersections for each of the seven populations investigated.

To use these graphs in the determination of the sample size required to estimate the total cost of improving the street sections or intersections in a given category, a decision must first be made as to the amount of error which can be tolerated. After the tolerable error for the total cost is determined, this value is divided by the number of street sections or intersections in that classification. This figure is the allowable error per street section or intersection and represents the product of the standard error of the mean and the Student's 't' deviate for the confidence interval involved in the desired estimation. The tolerable error per street section or intersection is divided by the Student's 't' deviate to obtain the standard error of the mean which is noted on the proper graph and projected up to the curve. From this point on the curve a line is projected to the percentage of sample size scale on the left side of the graph. This percentage value indicates the size of sample needed to make a reasonable estimate of the total cost required to improve the present deficiencies in the street sections or intersections being investigated. Each graph has a dashed line to indicate the lower limit of sample normality. Below this line the sampling distribution significantly departs from a normal distribution.

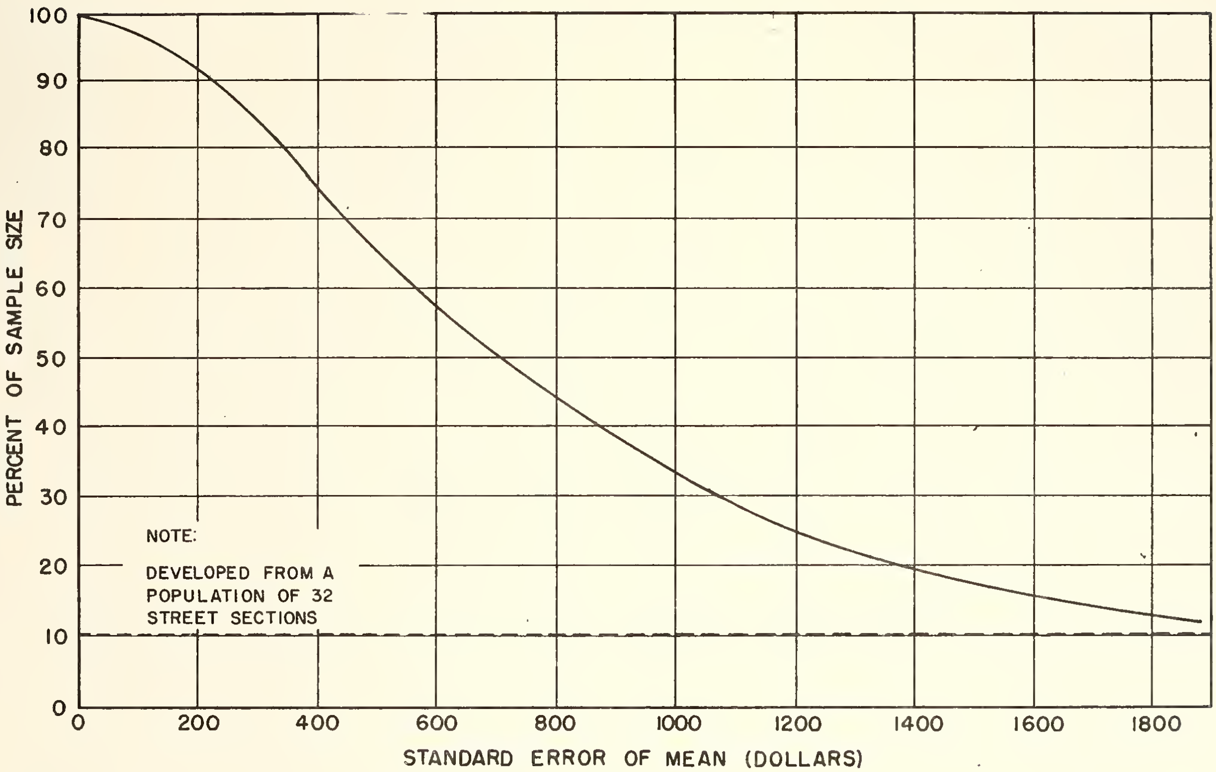

FIGURE 8. PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER STREET SECTION FOR COLLECTOR STREETS